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(54) **DEVICE FOR AND METHOD OF NETWORK ROUTING**

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See application file for complete search history.

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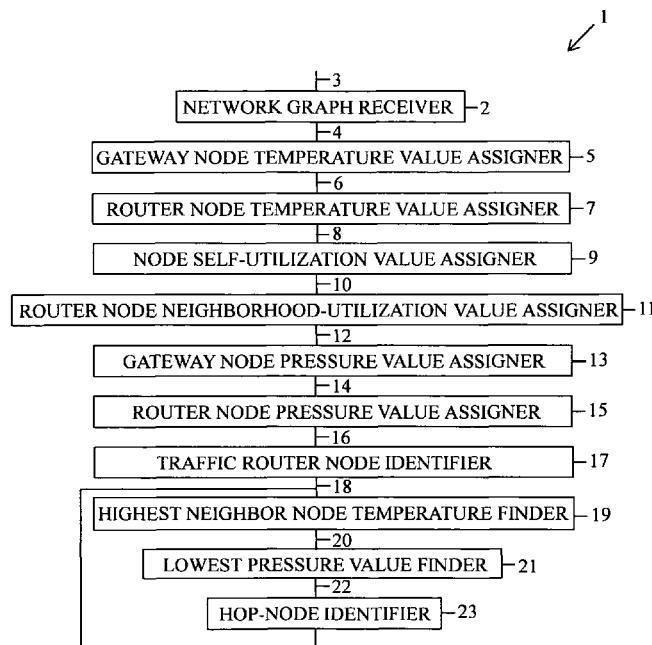
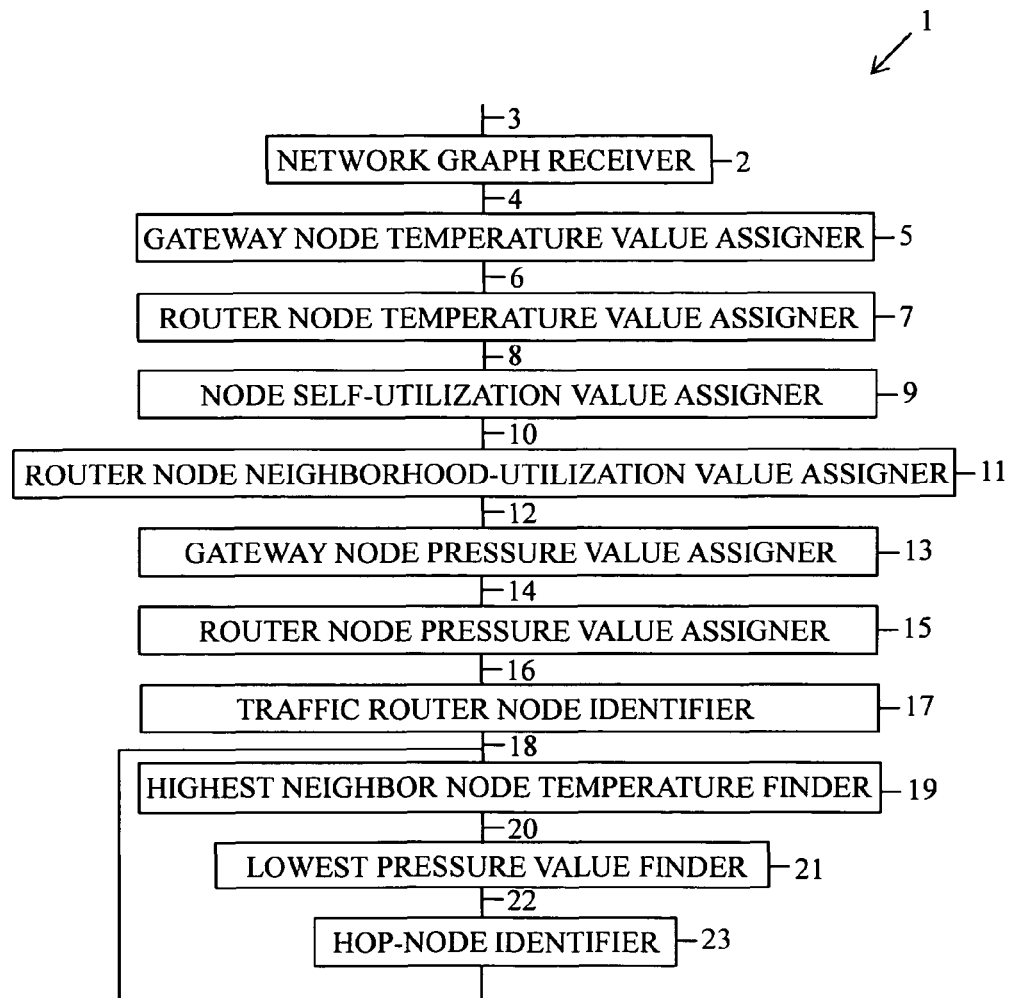* cited by examiner

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(57) **ABSTRACT**

A device and method of routing traffic in a network by receiving the network, assigning a maximum temperature value to gateway nodes, calculating temperature values for router nodes, determining self-utilization values for nodes, determining neighborhood-utilization values for router nodes, determining pressure values for gateway nodes, determining pressure values for router nodes, identifying router node sent traffic, identifying neighboring nodes having higher temperatures than router node, identifying neighboring node with lowest pressure value, sending traffic to neighboring node with lowest pressure value, and stopping if the neighboring node is a gateway node, otherwise identifying the node as a router node and returning to the step of finding neighboring nodes.
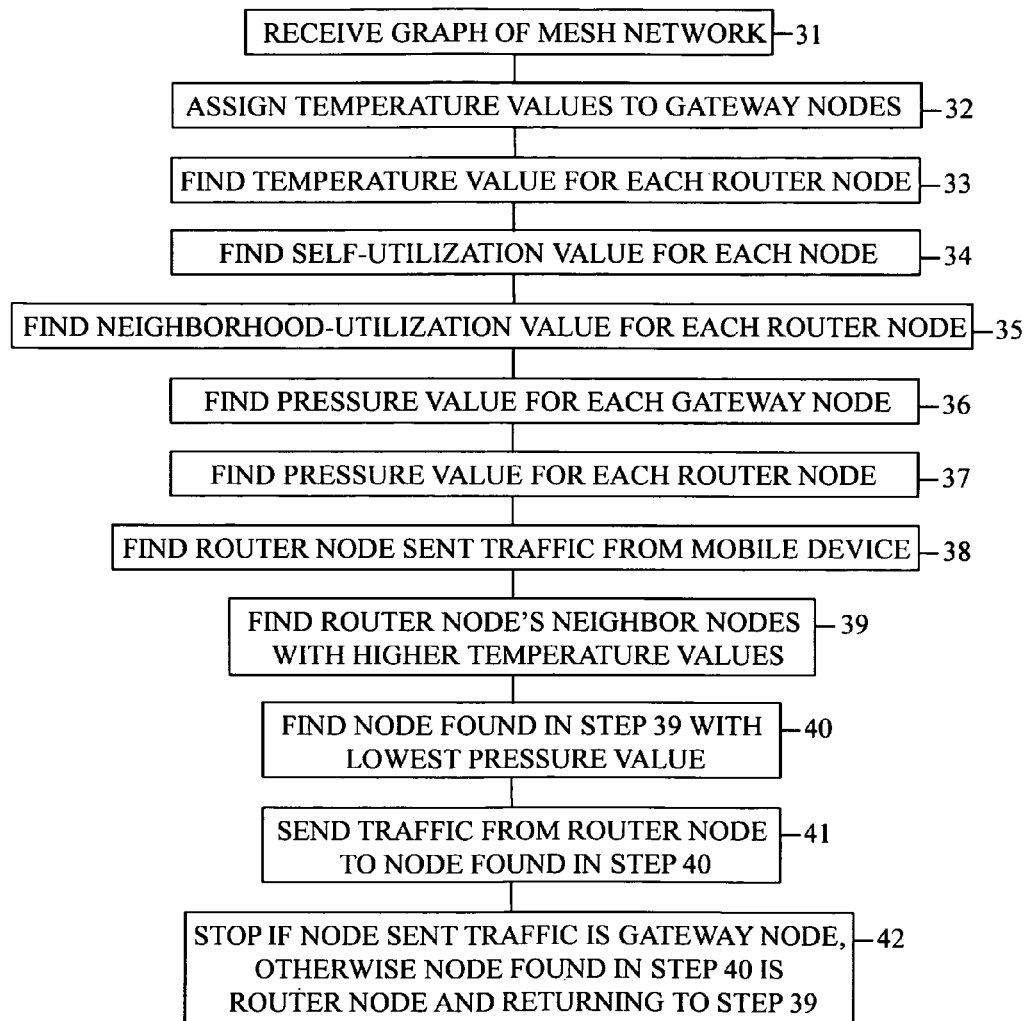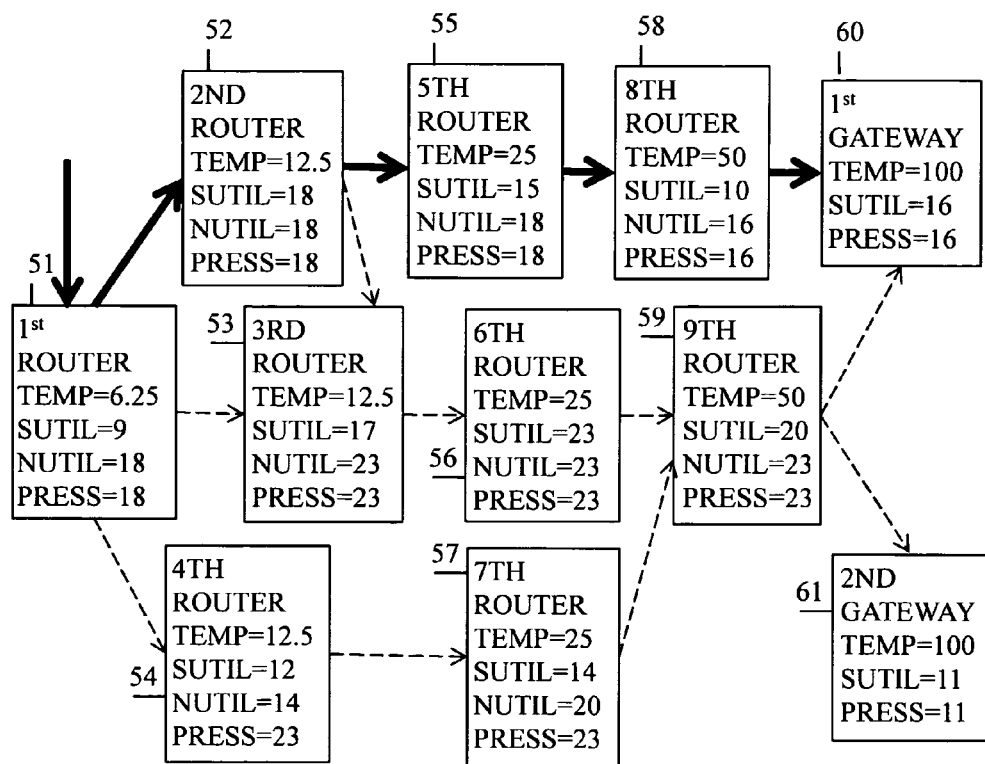
4 Claims, 3 Drawing Sheets

1

└3

| NETWORK GRAPH RECEIVER | ─2

└4

| GATEWAY NODE TEMPERATURE VALUE ASSIGNER | ─5

└6

| ROUTER NODE TEMPERATURE VALUE ASSIGNER | ─7

└8

| NODE SELF-UTILIZATION VALUE ASSIGNER | ─9

└10

| ROUTER NODE NEIGHBORHOOD-UTILIZATION VALUE ASSIGNER | ─11

└12

| GATEWAY NODE PRESSURE VALUE ASSIGNER | ─13

└14

| ROUTER NODE PRESSURE VALUE ASSIGNER | ─15

└16

| TRAFFIC ROUTER NODE IDENTIFIER | ─17

└18

| HIGHEST NEIGHBOR NODE TEMPERATURE FINDER | ─19

└20

| LOWEST PRESSURE VALUE FINDER | ─21

└22

| HOP-NODE IDENTIFIER | ─23

FIG. 1

RECEIVE GRAPH OF MESH NETWORK —31

ASSIGN TEMPERATURE VALUES TO GATEWAY NODES —32

FIND TEMPERATURE VALUE FOR EACH ROUTER NODE —33

FIND SELF-UTILIZATION VALUE FOR EACH NODE —34

FIND NEIGHBORHOOD-UTILIZATION VALUE FOR EACH ROUTER NODE —35

FIND PRESSURE VALUE FOR EACH GATEWAY NODE —36

FIND PRESSURE VALUE FOR EACH ROUTER NODE —37

FIND ROUTER NODE SENT TRAFFIC FROM MOBILE DEVICE —38

FIND ROUTER NODE'S NEIGHBOR NODES
WITH HIGHER TEMPERATURE VALUES —39

FIND NODE FOUND IN STEP 39 WITH
LOWEST PRESSURE VALUE —40

SEND TRAFFIC FROM ROUTER NODE
TO NODE FOUND IN STEP 40 —41

STOP IF NODE SENT TRAFFIC IS GATEWAY NODE,
OTHERWISE NODE FOUND IN STEP 40 IS
ROUTER NODE AND RETURNING TO STEP 39 —42

FIG. 2

52

2ND
ROUTER
TEMP=12.5
SUTIL=18
NUTIL=18
PRESS=18

55

5TH
ROUTER
TEMP=25
SUTIL=15
NUTIL=18
PRESS=18

58

8TH
ROUTER
TEMP=50
SUTIL=10
NUTIL=16
PRESS=16

60

1st
GATEWAY
TEMP=100
SUTIL=16
PRESS=16

51

1st
ROUTER
TEMP=6.25
SUTIL=9
NUTIL=18
PRESS=18

53

3RD
ROUTER
TEMP=12.5
SUTIL=17
NUTIL=23
PRESS=23

6TH
ROUTER
TEMP=25
SUTIL=23
NUTIL=23
PRESS=23

56

59

9TH
ROUTER
TEMP=50
SUTIL=20
NUTIL=23
PRESS=23

4TH
ROUTER
TEMP=12.5
SUTIL=12
NUTIL=14
PRESS=23

54

57

7TH
ROUTER
TEMP=25
SUTIL=14
NUTIL=20
PRESS=23

61

2ND
GATEWAY
TEMP=100
SUTIL=11
PRESS=11

FIG. 3

DEVICE FOR AND METHOD OF NETWORK ROUTING

FIELD OF INVENTION

The present invention relates, in general, to multiplex communications and, in particular, to flow control of data transmission through a network.

BACKGROUND OF THE INVENTION

Devices in a network may communicate with each other via hardwired transmission lines or over the air radio frequency (RF) transmission. Networks that communicate via RF transmission are referred to as wireless networks. Mobile devices communicate via numerous RF transmissions points commonly referred to as cells, where the mobile wireless network is commonly referred to as a wireless mesh network.

Mobile devices not only communicate with each other but can also be used to access the Internet. In a wireless mesh network, there are devices that provide access to the Internet, which are commonly referred to as access points or gateways, and there are device that merely route communication (i.e., traffic) to gateways, which are commonly referred to as routers of mobile nodes. With increased use of mobile devices, there is a need to route traffic in the most efficient manner.

In an article entitled "HEAT: Scalable Routing in Wireless Mesh Networks Using Temperature Fields," by Rainer Baumann et al., *Worlds of Wireless, Mobile and Multimedia Networks*, June 2007, a method was disclosed to assign a value referred to as a temperature to each mobile node, where gateways are assigned the maximum value and each mobile node is assigned a value that is a function of the values of all of its neighbors and a conductivity value. Therefore, the mobile nodes with more neighbors (i.e., more connections), tend to have higher temperatures than mobile nodes with fewer connections. Routing of mobile communications then proceeds from mobile nodes with lower temperatures to mobiles nodes with higher temperatures, always choosing the hottest node when routing, until the hottest mobile node (i.e., a gateway) is reached. Since mobile nodes with more connections tend to carry the most traffic and hence are the most congested, there is a need for a device and method that considers traffic congestion in determining routing in a mobile mesh network. The present invention is such a device and method.

In an article entitled "An Improved AODV Routing Protocol Based on the Congestion Control and Routing Repair Mechanism," by Li Xia et al., 2009 *International Conference on Communications and Mobile Computing*, IEEE Computer Society, an improved AODV routing protocol for mobile ad-hoc networks (MANETs) named AODV-I was disclosed.

In an article entitled "Hop-by-hop Congestion Control over a Wireless Multi-hop Network," by Yung Yi et al., 2009 *International Conference on Communications and Mobile Computing*, Proceeding of the IEEE Infocom, Hong Kong, March 2004, an algorithm to control congestion in multi-hop wireless networks.

U.S. Pat. No. 6,314,093, entitled "TRAFFIC ROUTE FINDER IN COMMUNICATIONS NETWORK," discloses a route finder means that associates a cost to each network link. U.S. Pat. No. 6,314,093 is hereby incorporated by reference into the specification of the present invention.

U.S. Pat. No. 6,509,898, entitled "USAGE BASED METHODS OF TRAVERSING AND DISPLAYING GENERALIZED GRAPH STRUCTURES," discloses a method of generating a tree structure representation of a generalized

graph structure for display that includes the more important links in the representation. U.S. Pat. No. 6,509,898 is hereby incorporated by reference into the specification of the present invention.

U.S. Pat. No. 7,639,662, entitled "QUALITY OF SERVICE CONGESTION METRICS PROPAGATED USING ROUTING UPDATES SYSTEM AND METHOD," discloses a device for and method of generating congestion metric information based on the utilization of a link to each of its neighbors. U.S. Pat. No. 7,639,662 is hereby incorporated by reference into the specification of the present invention.

U.S. Pat. No. 7,693,064, entitled "FORWARDING PACKETS TO A DIRECTED ACYCLIC GRAPH DESTINATION USING LINK SELECTION BASED ON RECEIVED LINK METRICS," discloses a method that utilizes path performance metrics. U.S. Pat. No. 7,693,064 is hereby incorporated by reference into the specification of the present invention.

U.S. Pat. No. 7,843,834, entitled "USE OF MINIMAL PROPAGATION DELAY PATH TO OPTIMIZE A MESH NETWORK," discloses a method that utilizes a minimal propagation delay path to optimize a mesh network. U.S. Pat. No. 7,843,834 is hereby incorporated by reference into the specification of the present invention.

SUMMARY OF THE INVENTION

It is an object of the present invention to route traffic in a mobile mesh network.

It is another object of the present invention to route traffic in a mobile mesh network as a function of node type, temperature value, and pressure value, where pressure value is a function of utilization value.

The present invention is a device for and a method of routing traffic in a mobile mesh network from a router node to a gateway node and vice versa.

The device and method each implement a method where the first step is receiving a graph of a mesh network, where the network includes at least one node of a first type and at least one node of a second type, where the node of the first type is a router node, where the node of the second type is a gateway node, and where nodes are neighbors if they can communicate with each other.

The second step implemented by the device and method is assigning a maximum user-definable temperature value to each gateway node.

The third step implemented by the device and method is calculating a temperature for each router node, where the temperature value for each router node is the highest temperature of a neighboring node times a user-definable conductivity value.

The fourth step implemented by the device and method is determining a self-utilization value for each router node and each gateway node, where the self-utilization value for each node (i.e., each router node and each gateway node) is a user-definable percentage of the total time that the node spends transmitting, receiving, and waiting because a neighboring node of the node in question is transmitting.

The fifth step implemented by the device and method is determining a neighborhood-utilization value for each router node, where the neighborhood-utilization value for each router node is a maximum of the router node's self-utilization value and the self-utilization values of all of its neighboring nodes (i.e., each neighboring router node and each neighboring gateway node, if any).

The sixth step implemented by the device and method is determining a pressure value for each gateway node, where the pressure value for each gateway node is the gateway node's self-utilization value.

The seventh step implemented by the device and method is determining a pressure value for each router node, where the pressure value for each router node is a function of the router node's neighborhood-utilization value and the pressure values of the router node's neighboring nodes that have higher temperature values than the router node's temperature value. First, for each router node, identifying the router node's neighboring nodes that have higher temperature values than the router node's temperature value. Second, identifying pressure values associated with such neighboring nodes. Third, identifying the minimum of the identified pressures values. Fourth, comparing the minimum pressure value identified to the router node's neighborhood-utilization value. Fifth, if the router node's neighborhood-utilization value is greater than or equal to the minimum of the identified pressure values then setting the router node's pressure value to the router node's neighborhood-utilization value. Sixth, if the minimum of the identified pressure values is greater than the router node's neighborhood-utilization value then setting the router node's pressure value to the minimum of the identified pressure values.

The eighth step implemented by the device and method is identifying a router node that was sent traffic from a mobile device.

The ninth step implemented by the device and method is identifying each node in the mesh network that is a neighbor node of the router node identified in the last step that has a higher temperature than the router node.

The tenth step implemented by the device and method is identifying the node identified in the ninth step that has the lowest pressure value.

The eleventh step implemented by the device and method is sending traffic from the router node involved in the ninth step to the node identified in the tenth step.

The twelfth step implemented by the device and method is stopping if the node to which traffic was sent in the eleventh step is a gateway node. Otherwise, identifying the node identified in the tenth step as a router node and returning to the ninth step.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic of the device of the present invention;

FIG. 2 is a flow-chart of the method of the present invention; and

FIG. 3 is an illustration of the operation of the present invention.

DETAILED DESCRIPTION

The present invention is a device for and a method of routing traffic in a mobile mesh network from a router node to a gateway node.

FIG. 1 is a schematic of the preferred device 1 of the present invention.

The device 1 includes a network-graph receiver 2 for receiving a graph of a mesh network, where the network includes at least one node of a first type and at least one node of a second type, where the node of the first type is a router node, where the node of the second type is a gateway node, and where nodes are neighbors if they can communicate with each other. The network-graph receiver 2 has an input 3 and has an output 4.

The device 1 also includes a gateway node temperature value assigner 5 for assigning a maximum user-definable temperature value to each gateway node. The gateway node temperature value assigner 5 has an input connected to the output 4 of the network graph receiver 2 and has an output 6.

The device 1 also includes a router node temperature value assigner 7 for calculating a temperature for each router node, where the temperature value for each router node is the highest temperature of a neighboring node times a user-definable conductivity value. The router node temperature value assigner 7 has an input connected to the output 6 of the gateway node temperature value assigner 5 and has an output 8.

The device 1 also includes a node self-utilization value assigner 9 for determining a self-utilization value for each node (i.e., each router node and each gateway node), where the self-utilization value for each node (i.e., each router node and each gateway node) is a user-definable percentage of a total time that the node spends transmitting, receiving, and waiting because a neighboring node is transmitting. The node self-utilization value assigner 9 has an input connected to the output 8 of the router node temperature value assigner 7 and has an output 10.

The device 1 also includes a router node neighborhood-utilization value assigner 11 for determining a neighborhood-utilization value for each router node, where the neighborhood-utilization value for each router node is a maximum of the router node's self-utilization value and the self-utilization values of all of its neighboring nodes (i.e., each router node and each gateway node, if any, that is a neighbor node of the router node for which a neighborhood-utilization value is being assigned). The router node neighborhood-utilization value assigner 11 has an input connected to the output 10 of the node self-utilization value assigner 9 and has an output 12.

The device 1 also includes a gateway node pressure value assignor 13 for determining a pressure value for each gateway node, where the pressure value for each gateway node is the gateway node's self-utilization value. The gateway node pressure value assignor 13 has an input connected to the output 12 of the router node neighborhood-utilization value assigner 11 and has an output 14.

The device 1 also includes a router node pressure value assigner 15 for determining a pressure value for each router node, where the pressure value for each router node is a function of the router node's neighborhood-utilization value and the pressure values of the router's neighboring nodes that have higher temperature values than the router node's temperature value. First, for each router node, identifying the router node's neighboring nodes that have higher temperature values than the router node's temperature value. Second, identifying pressure values associated with such neighboring nodes. Third, identifying the minimum of the identified pressures values. Fourth, comparing the minimum pressure value identified to the router node's neighborhood-utilization value. Fifth, if the router node's neighborhood-utilization value is greater than or equal to the minimum of the identified pressure values then setting the router node's pressure value to the router node's neighborhood-utilization value. Sixth, if the minimum of the identified pressure values is greater than the router node's neighborhood-utilization value then setting the router node's pressure value to the minimum of the identified pressure values. The router node pressure value assigner 15 has an input connected to the output 14 of the gateway node pressure value assigner 13 and has an output 16.

The device 1 includes a traffic router node identifier 17 for identifying a router node that was sent traffic from a mobile device. The traffic router node identifier 17 has an input

connected to the output **16** of the router node pressure value assigner **15** and has an output **18**.

The device **1** includes a highest neighbor node temperature finder **19** for identifying each node in the mesh network that is a neighbor node of the router node identified in the last step that has a higher temperature than the router node. The highest neighbor node temperature finder **19** has an input bus connected to the output **18** of the traffic router node identifier **17** and has an output **20**.

The device **1** includes a lowest pressure value finder **21** for identifying the node identified by the highest neighbor node temperature finder **19** that has the lowest pressure value. The lowest pressure value finder **21** has an input connected to the output **20** of the highest neighbor node temperature finder **19** and has an output **22**.

The device **1** includes a hop-node identifier **23** for sending traffic from the router node identified by the traffic router node identifier **17** to the node identified by the lowest pressure value finder **21**. The hop-node identifier **23** has an input connected to the output **22** of the lowest pressure value finder **21** and has an output connected to the input bus of the highest neighbor node temperature finder **19**. If the node to which traffic was sent is a gateway node then the device stops. Otherwise, the node identified by the lowest pressure value finder is a router node and operation of the device **1** returns to the highest neighbor node temperature finder **19**.

FIG. **2** is a flow-chart of the method of the present invention.

The first step **31** of the method is receiving a graph of a mesh network, where the network includes at least one node of a first type and at least one node of a second type, where the node of the first type is a router node, where the node of the second type is a gateway node, and where nodes are neighbors if they can communicate with each other.

The second step **32** of the method is assigning a maximum user-definable temperature value to each gateway node.

The third step **33** of the method is calculating a temperature for each router node, where the temperature value for each router node is the highest temperature of a neighboring node times a user-definable conductivity value.

The fourth step **34** of the method is determining a self-utilization value for each node (i.e., each router node and each gateway node), where the self-utilization value for each node (i.e., each router node and each gateway node) is a user-definable percentage of a total time that the node spends transmitting, receiving, and waiting because a neighboring node of the node in question is transmitting.

The fifth step **35** of the method is determining a neighborhood-utilization value for each router node, where the neighborhood-utilization value for each router node is a maximum of the router node's self-utilization value and the self-utilization values of all of its neighboring nodes (i.e., each neighboring router node and each neighboring gateway node, if any).

The sixth step **36** of the method is determining a pressure value for each gateway node, where the pressure value for each gateway node is the gateway node's self-utilization value.

The seventh step **37** of the method is determining a pressure value for each router node, where the pressure value for each router node is a function of the router node's neighborhood-utilization value and pressure values of the router node's neighboring nodes that have higher temperature values than the router node's temperature value. First, for each router node, identifying the router node's neighboring nodes that have higher temperature values than the router node's temperature value. Second, identifying pressure values asso-

ciated with such neighboring nodes. Third, identifying the minimum of the identified pressures values. Fourth, comparing the minimum pressure value identified to the router node's neighborhood-utilization value. Fifth, if the router node's neighborhood-utilization value is greater than or equal to the minimum identified pressure value then setting the router node's pressure value to the router node's neighborhood-utilization value. Sixth, if the minimum identified pressure value is greater than the router node's neighborhood-utilization value then setting the router node's pressure value to the minimum identified pressure value.

The eighth step **38** of the method is identifying a router node that was sent traffic from a mobile device.

The ninth step **39** of the method is identifying each node in the mesh network that is a neighbor node of the router node identified in the last step (which would be the ninth step **39** for the first pass through the method and would be the twelfth step **42** described below for any subsequent pass through the method) that has a higher temperature than the router node.

The tenth step **40** of the method is identifying the node identified in the ninth step **39** that has the lowest pressure value.

The eleventh step **41** of the method is sending traffic from the router node involved in the ninth step **39** to the node identified in the tenth step **40**.

The twelfth step **42** of the method is stopping if the node to which traffic was sent in the eleventh step **41** is a gateway node. Otherwise, identifying the node identified in the tenth step **40** as a router node and returning to the ninth step **39**.

FIG. **3** is an illustration of the operation of the present device **1** of FIG. **1** and the method of FIG. **2**.

In FIG. **3**, a mobile mesh network is received having a first router node **51**, a second router node **52**, a third router node **53**, a fourth router node **54**, a fifth router node **55**, a sixth router node **56**, a seventh router node **57**, an eighth router node **58**, a ninth router node **59**, a first gateway node **60**, and a second gateway node **61**. A line between two nodes indicates that those nodes can communicate with each other and are, therefore, neighboring nodes. That is, the first router node **51** is connected to the second router node **52**, the third router node **53**, and the fourth router node **54**. The second router node **52** is connected to the first router node **51**, the third router node **53**, and the fifth router node **55**. The third router node **53** is connected to the first router node **51** and the sixth router node **56**. The fourth router node **54** is connected to the first router node **51** and the seventh router node **57**. The fifth router node **55** is connected to the second router node **52** and the eighth router node **58**. The sixth router node **56** is connected to the second router node **52**, the third router node **53**, and the ninth router node **59**. The seventh router node **57** is connected to the fourth router node **54** and the ninth router node **59**. The eighth router node **58** is connected to the fifth router node **55** and the first gateway node **60**. The ninth router node **59** is connected to the sixth router node **56**, the seventh router node **57**, the first gateway node **60**, and the second gateway node **61**. The first gateway node **60** is connected to the eighth router node **58** and the ninth router node **59**. The second gateway node **61** is connected to the ninth router node **59**.

The first gateway nodes **60** and the second gateway node **61** are each assigned a highest user-definable temperature value (e.g., **100**).

The router nodes **51-59** are each assigned a temperature, where the temperature for a router node is the highest temperature of a neighboring node of the router node times a conductivity value (e.g., 0.5). So, working backwards from the first gateway node **60** and the second gateway node **61**, the

eighth router node **58** and the ninth router node **59** would each have a temperature of 50 (i.e., 100×0.5=50). The fifth router node **55**, the sixth router node **56**, and the seventh router node **57** would each have a temperature of 25 (i.e., 50×0.5=25). The second router node **52**, the third router node **53** and the fourth router node **54** would each have a temperature of 12.5 (i.e., 25×0.5=12.5). The first router node **51** would have a temperature of 6.25 (i.e., 12.5×0.5=6.25).

A self-utilization value for each node (i.e., each router node **51-59** and each gateway node **60,61**) is determined, where the self-utilization value for each node (i.e., each router node **51-59** and each gateway node **60,61**) is a user-definable percentage of a total time that the node in question spends transmitting, receiving, and waiting because a neighboring node of the node in question is transmitting. For FIG. 3, the self-utilization values (SUTILs) are as follows: 9 for the first router node **51**, 18 for the second router node **52**, 17 for the third router node **53**, 12 for the fourth router node **54**, 15 for the fifth router node **55**, 23 for the sixth router node **56**, 14 for the seventh router node **57**, 10 for the eighth router node **58**, 20 for the ninth router node **59**, 16 for the first gateway node **60**, and 11 for the second gateway node **61**.

A neighborhood-utilization value for each router node **51-59** is determined, where the neighborhood-utilization value for a router node is the maximum of the router node's self-utilization value and the self-utilization values of all of its neighboring nodes. For FIG. 3, the neighborhood-utilization value for the first router node **51** is 18, because the self-utilization value 18 of the second router node **52** is greater than the first router node's **51** self-utilization value 9 and the self-utilization values 17 and 12 of the first router node's **51** other neighboring nodes (i.e., the third router node **53** and the fourth router node **54**, respectively). The neighborhood-utilization value for the second router node **52** is 18, because the self-utilization value 18 of the second router node **52** is greater than the first router node's **51** self-utilization value 9 and the self-utilization values 17 and 15 of the second router node's **52** other neighboring nodes (i.e., the third router node **53** and the fifth router node **55**, respectively). The neighborhood-utilization value for the third router node **53** is 23, because the self-utilization value 23 of the sixth router node **56** is greater than the third router node's **51** self-utilization value 17 and the self-utilization values 9 and 18 of the third router node's **53** other neighboring nodes (i.e., the first router node **51** and the second router node **52**, respectively). The neighborhood-utilization value for the fourth router node **54** is 14, because the self-utilization value 14 of the seventh router node **57** is greater than the fourth router node's **54** self-utilization value 12 and the self-utilization value 9 of the fourth router node's **54** other neighboring node (i.e., the first router node **51**). The neighborhood-utilization value for the fifth router node **55** is 18, because the self-utilization value 18 of the second router node **52** is greater than the fifth router node's **55** self-utilization value 15 and the self-utilization value 10 of the fifth router node's **55** other neighboring node (i.e., the eighth router node **58**). The neighborhood-utilization value for the sixth router node **56** is 23, because the self-utilization value 23 of the sixth router node **56** is greater than the self-utilization values 17 and 20 of the sixth router node's **56** other neighboring nodes (i.e., the third router node **53** and the ninth router node **59**, respectively). The neighborhood-utilization value for the seventh router node **57** is 20, because the self-utilization value 20 of the ninth router node **59** is greater than the self-utilization value 14 of the seventh router node **57** and the self-utilization value 12 of the seventh router node's **57** other neighboring node (i.e., the fourth router node **54**). The neighborhood-utilization value for the eighth router

node **58** is 16, because the self-utilization value 16 of the first gateway node **56** is greater than the self-utilization value 10 of the eighth router node **58** and the self-utilization value 15 of the eighth router node's **58** other neighboring node (i.e., the fifth router node **55**). The neighborhood-utilization value for the ninth router node **59** is 23, because the self-utilization value 23 of the sixth router node **56** (i.e., a neighboring node of the ninth router node **59**) is greater than the self-utilization value 20 of the ninth router node **59** and the self-utilization values 14, 16, and 11 of the ninth router node's **59** other neighboring nodes (i.e., the seventh router node **57**, the first gateway node **60**, and the second gateway node **61**, respectively).

A pressure value for each gateway node **60, 61** is determined, where the pressure value for each gateway node **60, 61** is the self-utilization value of the gateway node **60, 61** in question. Therefore, the pressure value for the first gateway node **60** is 16, because the first gateway node's **60** self-utilization value is 16. The pressure value for the second gateway node **61** is 11, because the second gateway node's **61** self-utilization value is 11.

A pressure value is determined for each router node **51-59**, where the pressure value for each router node **51-59** is determined by, first, identifying the router node's neighboring nodes with higher temperatures than the router node. Second, identifying pressure values associated with such neighboring nodes. Third, identifying the minimum of the identified pressures values. Fourth, comparing the minimum pressure value identified to the router node's neighborhood-utilization value. Fifth, if the router node's neighborhood-utilization value is greater than or equal to the minimum identified pressure value then setting the pressure value for the router node to the router node's neighborhood-utilization value. Sixth, if the minimum identified pressure value is greater than the neighborhood-utilization value then setting the pressure value for the router node to the minimum identified pressure value. The pressure value of the first router node **51** is 18, because the first router node's **51** neighborhood-utilization value 18 is equal to the minimum pressure value 18 (i.e., of the second router node **52**) of its neighboring nodes (i.e., the second router node **52**, the third router node **53**, and the fourth router node **54**) that have a higher temperature value (i.e., 12.5 for each neighboring node) than the first router node **51** (i.e., 6.25). The pressure value of the second router node **52** is 18, because the second router node's **52** neighborhood-utilization value 18 is equal to the minimum pressure value 18 (i.e., of the fifth router node **55**) of its neighboring node (i.e., the fifth router node **55**) that has a higher temperature value (i.e., 25) than the second router node **52** (i.e., 12.5). The pressure value of the third router node **53** is 23, because the third router node's **53** neighborhood-utilization value 23 is equal to the minimum pressure value 23 (i.e., of the sixth router node **56**) of its neighboring node (i.e., the sixth router node **56**) that has a higher temperature value (i.e., 25) than the third router node **53** (i.e., 12.5). The pressure value of the fourth router node **54** is 23, because the minimum pressure value 23 of the fourth router node's **54** neighboring node (i.e., the seventh router node **57**) that has a higher temperature value (i.e., 25) than the fourth router node **54** (i.e., 12.5) is greater than the neighborhood-utilization value 14 of the fourth router node **54**. The pressure value of the fifth router node **55** is 18, because the fifth router node's **55** neighborhood-utilization value 18 is greater than the minimum pressure value 16 of its neighboring node (i.e., the eighth router node **58**) that has a higher temperature value (i.e., 50) than the fifth router node **55** (i.e., 25). The pressure value of the sixth router node **56** is 23, because the sixth router node's **56** neighborhood-utilization

value 23 is equal to the minimum pressure value 23 of its neighboring node (i.e., the ninth router node **59**) that has a higher temperature value (i.e., 50) than the sixth router node **56** (i.e., 25). The pressure value of the seventh router node **57** is 23, because the minimum pressure value 23 of the seventh router node's **57** neighboring node (i.e., the ninth router node **59**) that has a higher temperature value (i.e., 50) than the seventh router node **57** (i.e., 25) is greater than the neighborhood-utilization value 20 of the seventh router node **57**. The pressure value of the eighth router node **58** is 16, because the eighth router node's **58** neighborhood-utilization value 16 is equal to the minimum pressure value 16 of its neighboring node (i.e., the first gateway node **60**) that has a higher temperature value (i.e., 100) than the eighth router node **58** (i.e., 50). The pressure value of the ninth router node **59** is 23, because the ninth router node's **59** neighborhood-utilization value 23 is greater than the minimum pressure value 11 (i.e., the pressure value 11 of the second gateway node **61** is less than the pressure value 16 of the first gateway node **60**) of its neighboring nodes (i.e., the first gateway node **60** and the second gateway node **61**) that has a higher temperature value (i.e., 100) than the ninth router node **59** (i.e., 50).

The bolded arrow pointing to the first router node **51** indicates that the first router node **51** was sent traffic from a mobile device.

The nodes in the mesh network that are neighboring nodes of the first router node **51** are the second, third, and forth router nodes **52**, **53**, **54**.

The second router node **52** has the lowest pressure value 18 of the second, third, and fourth router nodes **52**, **53**, **54**.

The traffic received by the first router node **51** is sent to the second router node **52**, as indicated by the bolded connection.

Since the second router node **52** is not a gateway node, it is identified as a router node and operation of the method and device continues.

The nodes in the mesh network that are neighboring nodes of the second router node **52** are the third and fifth router nodes **53**, **55**.

The fifth router node **55** has the lowest pressure value 18 of the third and fifth router nodes **53**, **55**.

The traffic received by the second router node **52** is sent to the fifth router node **55**, as indicated by the bolded connection.

Since the fifth router node **55** is not a gateway node, it is identified as a router node and operation of the method and device continues.

The node in the mesh network that is a neighboring node of the fifth router node **55** is the eighth router node **58**.

The eighth router node **58** has the lowest, and only, pressure value 16 of a router node connected to the fifth router node **55**.

The traffic received by the fifth router node **55** is sent to the eighth router node **58**.

Since the eighth router node **58** is not a gateway node, it is identified as a router node and operation of the method and device continues.

The node in the mesh network that is a neighboring node of the eighth router node **58** is the first gateway node **60**.

The first gateway node **60** has the lowest, and only, pressure value 16 of a node connected to the eighth router node **58**.

The traffic received by the eighth router node **58** is sent to the first gateway node **60**.

Since the first gateway node **60** is a gateway node, operation of the method and device stops.

What is claimed is:

1. A device for routing traffic in a mobile mesh network, comprising:

a) a network-graph receiver for receiving a graph of a mesh network, where the network includes at least one node of a first type and at least one node of a second type, where the node of the first type is a router node, where the node of the second type is a gateway node, and where nodes are neighbors if they can communicate with each other, having an input, and having an output;

b) a gateway node temperature value assigner for assigning a maximum user-definable temperature value to each gateway node, having an input connected to the output of the network graph receiver, and having an output;

c) a router node temperature value assigner for calculating a temperature for each router node, where the temperature value for each router node is the highest temperature of a neighboring node times a user-definable conductivity value, having an input connected to the output of the gateway node temperature value assigner, and having an output;

d) a node self-utilization value assigner for determining a self-utilization value for each router node and each gateway node, where the self-utilization value for each node is a user-definable percentage of a total time that the node spends transmitting, receiving, and waiting while the node's neighboring node is transmitting, having an input connected to the output of the router node temperature value assigner, and having an output;

e) a router node neighborhood-utilization value assigner for determining a neighborhood-utilization value for each router node, where the neighborhood-utilization value for each router node is a maximum of the router node's self-utilization value and the self-utilization values of all of its neighboring nodes, having an input connected to the output of the self-utilization value assigner, and having an output;

f) a gateway node pressure value assignor for determining a pressure value for each gateway node, where the pressure value for each gateway node is the gateway node's self-utilization value, having an input connected to the output of the router node neighborhood-utilization value assigner, and having an output;

g) a router node pressure value assigner for determining a pressure value for each router node, where the pressure value for each router node is a function of the neighborhood-utilization value of the router node and pressure values of the router node's neighboring nodes that have higher temperature values than the router node's temperature value, having an input connected to the output of the gateway node pressure value assigner, and having an output;

h) a traffic router node identifier for identifying a router node that was sent traffic from a mobile device, having an input connected to the output of the router node pressure value assigner, and having an output;

i) a highest neighbor node temperature finder for identifying each node in the mesh network that is a neighbor node of the router node identified in the last operation of the device that has a higher temperature than the router node, having an input bus connected to the output of the traffic router node identifier, and having an output;

j) a lowest pressure value finder for identifying the node identified by the highest neighbor node temperature finder that has the lowest pressure value, having an input connected to the output of the highest neighbor node temperature finder, and having an output;

k) a hop-node identifier for sending traffic from the router node identified by the traffic router node identifier to the node identified by the lowest pressure value finder, hav-

ing an input connected to the output of the lowest pressure value finder, and having an output connected to the input bus of the output of the highest neighbor node temperature finder, where the device stops if the node to which traffic was sent is a gateway node, otherwise the node identified by the lowest pressure value finder is a router node and operation of the device returns to the highest neighbor node temperature finder.

2. The device of claim **1**, wherein said router node pressure value assigner is comprised of a router node pressure value assigner that identifies neighboring nodes with higher temperatures than the router node, identifies pressure values associated with such neighboring nodes, identifies the minimum of the identified pressures values, compares the minimum pressure value identified to the neighborhood-utilization value of the router node, setting the pressure value of the router node to the neighborhood-utilization value if the neighborhood-utilization value is greater than or equal to the minimum identified pressure value then, and setting the pressure value of the router node to the minimum identified pressure value if the minimum identified pressure value is greater than the neighborhood-utilization value.

3. A method of routing traffic in a mobile mesh network, comprising the steps of:

    a. receiving a graph of a mesh network, where the network includes at least one node of a first type and at least one node of a second type, where the node of the first type is a router node, where the node of the second type is a gateway node, and where nodes are neighbors if they can communicate with each other;

    b. assigning a maximum user-definable temperature value to each gateway node;

    c. calculating a temperature for each router node, where the temperature value for each router node is the highest temperature of a neighboring node times a user-definable conductivity value;

    d. determining a self-utilization value for each router node and each gateway node, where the self-utilization value for each node is a user-definable percentage of a time that the node spends transmitting, receiving, and waiting while its neighbor node is transmitting;

    e. determining a neighborhood-utilization value for each router node, where the neighborhood-utilization value

    for each router node is a maximum of the router node's self-utilization value and the self utilization values of all of its neighbor nodes, if any;

    f. determining a pressure value for each gateway node, where the pressure value for each gateway node is the gateway node's self-utilization value;

    g. determining a pressure value for each router node, where the pressure value for each router node is a function of the router node's neighborhood-utilization value and pressure values of the router node's neighbor nodes that have higher temperature values than the router node's temperature value;

    h. identifying a router node that was sent traffic from a mobile device;

    i. identifying each node in the mesh network that is a neighbor node of the router node identified in the most recently performed last step that has a higher temperature than the router node;

    j. identifying the node identified in step (i) that has the lowest pressure value;

    k. sending traffic from the router node involved in step (i) to the node identified in step (j); and

    l. stopping if the node to which traffic was sent in step (k) is a gateway node, otherwise identifying the node identified in step (j) as a router node and returning to step (i).

4. The method of claim **2**, wherein said step of determining a pressure value for each router node is comprised of the step of determining a pressure value for each router node by identifying neighboring nodes with higher temperatures than the router node, identifying pressure values associated with such neighboring nodes, identifying the minimum of the identified pressures values, comparing the minimum pressure value identified to the neighborhood-utilization value of the router node, setting the pressure value for the router node to the neighborhood-utilization value if the neighborhood-utilization value is greater than or equal to the minimum identified pressure value, and setting the pressure value for the router node to the minimum identified pressure value if the minimum identified pressure value is greater than the neighborhood-utilization value.

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